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EPA-Kawasaki Emission Measurement Comparison Test Program

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Three 1975 Kawasaki motorcycles were emission tested at Kawasaki Heavy Industries in Japan, and at EPA. The ANPRM test procedure, which predates the current procedure, was used. Emissions and fuel economy compared well between facilities with the exception of CO, which was significantly higher at EPA. Part of the difference is attributed to ambient pressure differences between facilities. It is recommended that factors describing the effect of ambient conditions on emissions and fuel economy be developed.

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EPA - Kawasaki Emission Measurement Comparison Test Program

Abstract

Three Kawasaki motorcycles were emission tested at Kawasaki Heavy Industries in Japan, and at EPA. Emissions and fuel economy compared well with the exception of CO emissions, which were significantly higher at the EPA facility. It is believed ambient pressure differences between facilities account for some of the difference in CO emissions.

Introduction

A comparison emission test program between EPA and Kawasaki Heavy Industries, Ltd using three Kawasaki motorcycles was requested by Kawasaki in early 1975. The motorcycles were tested in Japan by Kawasaki, and then shipped to EPA for comparison testing. The motorcycles, described in more detail in Appendix I, are a 903 cc Z-1, a 247 cc F-11, and a 174 cc F-7.

Program Objective

The objective of this test program was to assess the comparability of the two test facilities. A complete correlation program, which would include precise preconditioning, hot start tests, and gas cylinder cross checks, was not attempted.

Test Facilities

The test equipment and instrumentation used is presented in Table I. Although the Kawasaki test report, reference 1, does not identify the manufacturer of their dynamometer, the layout drawing indicates it is very similar to the Shibaura being used by EPA. The power absorbers are identical Clayton ECE-50 models.

Figure 1 presents the total absorbed power of the EPA dynamometer for the two power settings used. The Kawasaki data presented in reference 1 is nearly identical, indicating the absorbed power characteristics for testing were the same for both facilities.

Test Procedure

Kawasaki performed its tests per the "Draft Emission Regulation for Motorcycles", dated January 17, 1974. The tests at EPA duplicated the Kawasaki test procedure as reported in reference 1. A summary of the test conditions is presented in Table II.

The dynamometer absorbed power used for this test program (and specified in the Draft Regulations) is considerably lower than the dynamometer absorbed power specified in the NPRM, reference 2. The values in the NPRM are based on coast down tests performed by EPA, and are the most recent data available. Thus the emission and fuel economy values determined in this test program should be used only for facility comparisons, and are not representative of the emissions and fuel economy to be expected from testing these motorcycles per the NPRM. A comparison of the dynamometer absorbed power specifications is presented below.

Dynamometer Absorbed Power at 85 kph

Motorcycle	Inertia Class, kg	Total Absorbed Power, hp "Draft Rags" & as tested	HFRM
E-1	330	5.24	3.54
F-11	310	1.75	3.03
F-7	300	1.73	3.70

A 1974 model F7, which was loaned to EPA by Kawasaki, was coast down tested at the Transportation Research Center of Ohio. The results of this test are presented in Figure 2 along with the dynamometer power characteristics. As the figure shows, the road power determined from coast down testing is much better represented on the dynamometer by the HFRM specified power. The power setting, as specified in the Draft Regulations and used for this test program, is much lower than the motorcycle's actual road load power.

Test Results

For each motorcycle, the tests used for comparison consisted of the 2 cold-hot tests performed by Kawasaki and the three FTPs performed by EPA. The test results are summarized in Table III. The individual test sheets for the EPA tests are presented in Appendix II. A summary of the Kawasaki data, taken from reference 1, is presented as Appendix III.

Table IV presents a statistical comparison of the test data. A t-statistic and corresponding confidence level is presented. Large confidence levels indicate the means between test facilities are significantly different. The results for each of the three motorcycles and possible causes for significant differences are discussed below.

E-1: There is a significant difference between facilities for all parameters for this motorcycle. It is believed that the differences may be a result of a change in the motorcycle's operational performance. Upon receiving the motorcycle from Kawasaki, the E-1 was driven over a preparation LA-4 followed by 2 FTPs. The emission results from these first two tests were radically different than the results reported by Kawasaki in reference 1. HC was more than 3 times higher (15 g/km), CO was 25 percent lower (27 g/km), and NOx was 3 times higher (0.6g/km) than reported by Kawasaki. The results from the third test were similar to the Kawasaki results, indicating a major shift in performance had taken place. The fourth and fifth tests were consistent with the third test. The emission results of the first two tests are believable since testing of other motorcycles at EPA was yielding expected results, and no analysis problems were detected during the routine maintenance of equipment. Thus the significant difference between facilities determined from the E-1 testing is likely the result of a shift in the motorcycle's performance, and cannot be solely attributed to a facility difference.

F-11: All parameters except CO compare well between facilities. At a confidence level of 90 percent, the CO emissions between facilities are different. As Table IV shows, the average CO emissions at the EPA facility were 16 percent higher than at Kawasaki.

F-7: All parameters except CO and NOx compare well between facilities. The comparison of NOx emissions must be considered in light of the one significant figure reported for NOx in the Kawasaki report. The CO emissions are different at the 99.8 percent confidence level. The average CO emissions at the EPA facility were 30 percent higher than at Kawasaki.

In summary, the emissions and fuel economy compare well between facilities except for CO, which is different between facilities at the 90 percent confidence level.

An apparent difference between test conditions at the two facilities was the ambient pressure and temperature. On the average, the ambient pressure was 28 mm of mercury (1 inch Hg) higher and 6 degrees centigrade (10°F) lower at the Kawasaki facility. (The average ambient temperature at Kawasaki was 17°C, which is outside of the required test range of 20-30°C).

The effects of ambient conditions on motorcycle emissions have not yet been quantified. It is likely, however, that the ambient effects on motorcycle emissions will be similar to the ambient effects on light duty vehicle emissions, that is the trends may be expected to be the same. In an attempt to identify reasons for the differences in CO emission levels between facilities, the ambient correction factors determined in the 1975 EPA-U.S. MVMA correlation study (ref. 3) for light duty vehicles were applied to the F-7 and F-11 test data. With emissions corrected to the same ambient conditions, the confidence level that the CO emissions between facilities are different was reduced from 90 to 30 percent for the F-11 and from 99.85 to 99.8 percent for the F-7. The confidence level for HC emissions for the F-7 was increased from less than 20 percent to 95 percent; other confidence levels showed little change. These changes are due to ambient pressure only; correction factors for other ambient parameters were negligible (Ref. 3).

If these correction factors are applicable to motorcycles, then ambient pressure differences between facilities account for some of the differences in CO emissions. The quantitative use of these LDV correction factors for motorcycles is questionable, however the direction of the effect would seem applicable, and results in a reduction of the difference between facilities for CO emissions.

Summary and Conclusions

1. The facilities compared well with the exception of CO emissions.

2. CO emissions were significantly different between facilities, with EPA measuring higher CO emissions.

3. A large difference in test ambient pressure between facilities most likely accounts for some of the difference in CO emissions between facilities.

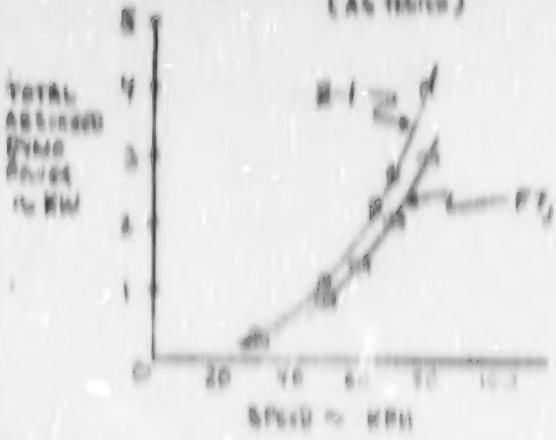
4. Because ambient correction factors for motorcycles are not available, the quantitative effect of the ambient pressure differences between facilities was not determined. Development of these factors for motorcycles is recommended.

5. The results of the 3-1 tests were not used due to a probable shift in engine performance which occurred during EPA testing.

6. It is recommended that additional correlation programs be performed as test facilities and procedures are changed and as low emission motorcycles become available.

Figure 1

Dynamometer Characteristics - EPA
(As tested)



The Kawasaki dynamometer power curve as presented as reference 1 is nearly identical.

Figure 2

Dynamometer and Tractive Absorbed Power Characteristics
F-7

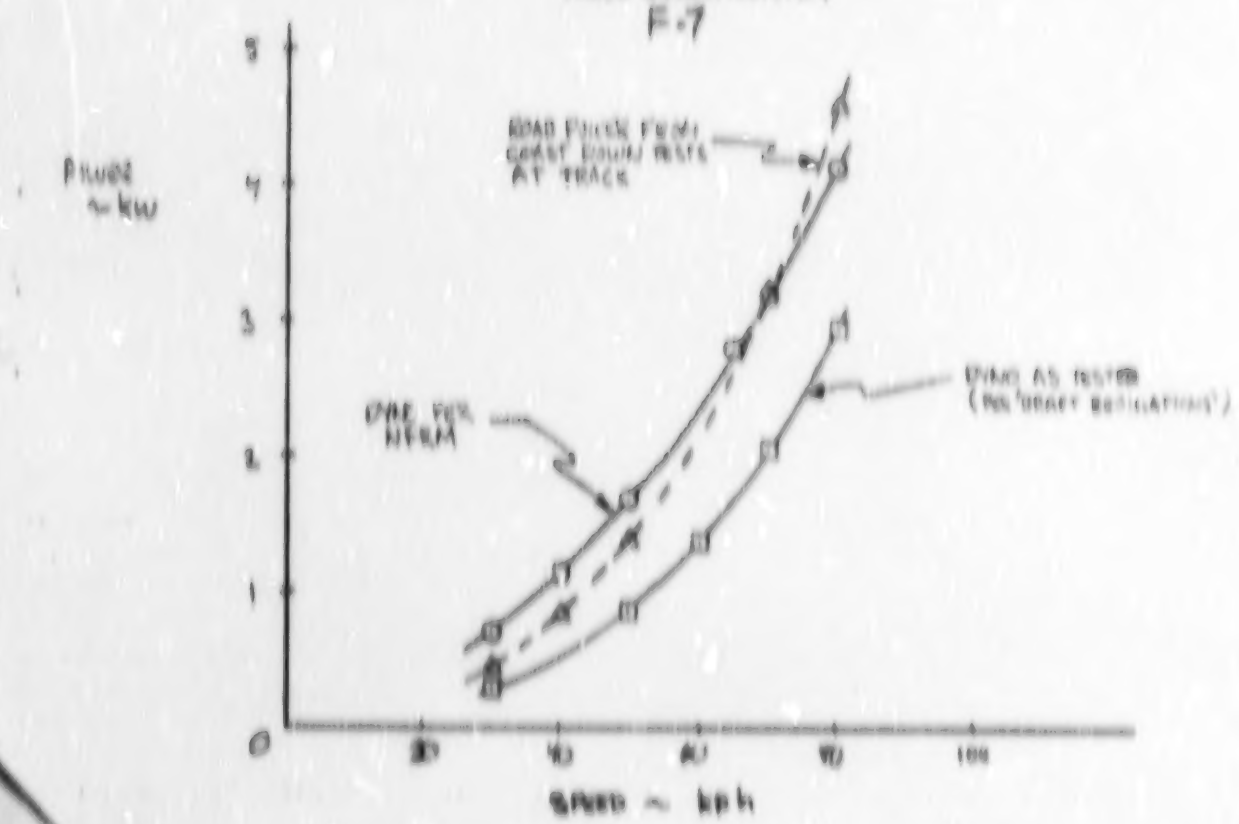


Table 1

Equipment and Instrumentation Comparison

	EPA	Kawasaki
Dynamometer	Shibaura DS-30 Clayton ECE 50 Power Absorber, Belt Driven Inertia Wheels, 530.5 mm Roll Diameter	Manufacturer not specified, Clayton ECE 50 Power Absorber, Belt Driven Inertia Wheels, 530.5 mm Roll Diameter.
CVS	AMI Positive Displacement Pump.	Beckman Toshiba Canvas - 3630 Positive Displacement Pump
Analysers		
HC	Beckman 400 FID; 0-100, 0-1000 ppm Hexane	Beckman Toshiba FID; 0-4, 0-20, 0-40, 0-200, 0-400, 0-2000 ppm Hexane.
CO	Beckman 315 NDIR; 0-2500 ppm	Beckman Toshiba NDIR, 0-200, 0-500 ppm*
CO_2	Beckman 315 NDIR; 0-1%	Beckman Toshiba NDIR, 0-4, 0-8, 0-16%.
NOx	TECO CL; 0-25, 0-100 ppm	Beckman Toshiba CL; 0-10, 0-25, 0-100, 0-250, 0-1000, 0-2500, 0-10000 ppm.

Kawasaki Data from Reference 1

*The test data sheets and calibration curves indicate 0-3000 and 0-8000 ppm ranges were used.

Table II

Test Conditions

	R-1	R-11	R-2
Inertia, kg	330	310	300
Absorbed Power @ 65 kph, kw	2.24 (3.0 hp)	1.75 (2.3 hp)	1.72 (2.3 hp)
Shift Points	Ref. 1	Ref. 1	Ref. 1
Choke Operation	Ref. 1	Ref. 1	Ref. 1
Rear Tire Pressure, kPa	214(31 psig)	214(31 psig)	193(28 psig)
Test Fuel	. . . . . Indolene 30		
Engine Oil	As Received	. . Kawasaki 2 Stroke . .	

Table III

Test Results

		HC	CO	CO_2	NOx	Fuel Economy
F-I						
Kawasaki	R	4.16	17.28	91.28	.19	14.3
	S	.007	.028	4.42	.014	.38
	SE	.16	.08	4.8	7.4	2.7
EPA	R	3.04	33.82	83.19	.22	16.1
	S	.15	.86	4.51	.006	.64
	SE	4.9	2.5	5.4	2.7	4.0
F-II						
Kawasaki	R	7.69	19.54	45.50	.02	23.7
	S	.424	.665	3.54	0	1.80
	SE	5.3	3.4	12.2	0	7.8
EPA	R	8.52	23.37	41.69	.019	22.3
	S	.60	1.98	2.51	.002	1.61
	SE	7.0	8.5	6.0	10.5	7.2
F-I						
Kawasaki	R	4.31	7.02	42.61	.02	35.1
	S	.240	.290	6.66	0	4.10
	SE	5.6	4.1	15.6	0	11.7
EPA	R	4.30	10.04	42.14	.027	32.8
	S	.11	.26	1.45	.002	.91
	SE	2.6	2.6	3.4	7.4	2.8

Note: Emissions in g/km
Fuel Economy in km/l
SE = s/R * 100

Table IV

Comparison of Test Results

	HC	CO	CO_2	NOx	Fuel Economy
$\bar{X}_{NAM} - \bar{X}_{EPA}$					
81	1.32	3.46	8.09	-.03	-1.6
F11	-.53	-3.81	1.81	.001	0.9
F7	.01	-3.03	0.47	-.007	2.3
$(\bar{X}_{NAM} - \bar{X}_{EPA})/\bar{X}_{EPA}$, %					
81	43.4	10.2	9.7	-13.6	-11.2
F11	-6.2	-16.4	9.1	5.3	4.0
F7	0.2	-30.1	1.1	-25.9	7.0
t statistic					
81	11.65	5.37	1.98	-3.10	-3.38
F11	-1.07	-2.53	1.10	.56	.56
F7	.07	-12.22	.13	-5.16	1.01
Confidence Level					
81	99.8	98	85	94	95
F11	60	90+	60	40	40
F7	<20	99.85	<20	98.5	60

References

1. 1st Engineering Dept. of Kawasaki Heavy Industries, GD, Ltd.; "Test Data of Exhaust Emissions from Motorcycles, Kawasaki S1, F11, F7" June 2, 1975.

2. Federal Register, Vol. 40, No. 205, October 23, 1975, pages 49490-49530.

3. Leiferman, H.W. and Wilson, G.H., "1975 EPA-U.S. HVMA Correlation Study", EPA, June, 1975.

Appendix I

Test Vehicle Description

Make	Kawasaki	Kawasaki	Kawasaki
Model Year	1975	1975	1975
Model	S-1	F-11	F-7
Type	Street	Enduro	Enduro
Engine Type	4s dohc	2s	2s reed valve
# of Cylinders	4	1	1
Displacement	903 cc	347 cc	174 cc
Horsepower	82	32	18
Compression Ratio	8.5:1	6.4:1	7:1
Ignition	Bat. & Coil	Magneto	CDI
Transmission	5 Speed	5 Speed	5 Speed
Inertia (incl. rider)	330 kg	310 kg	290 kg

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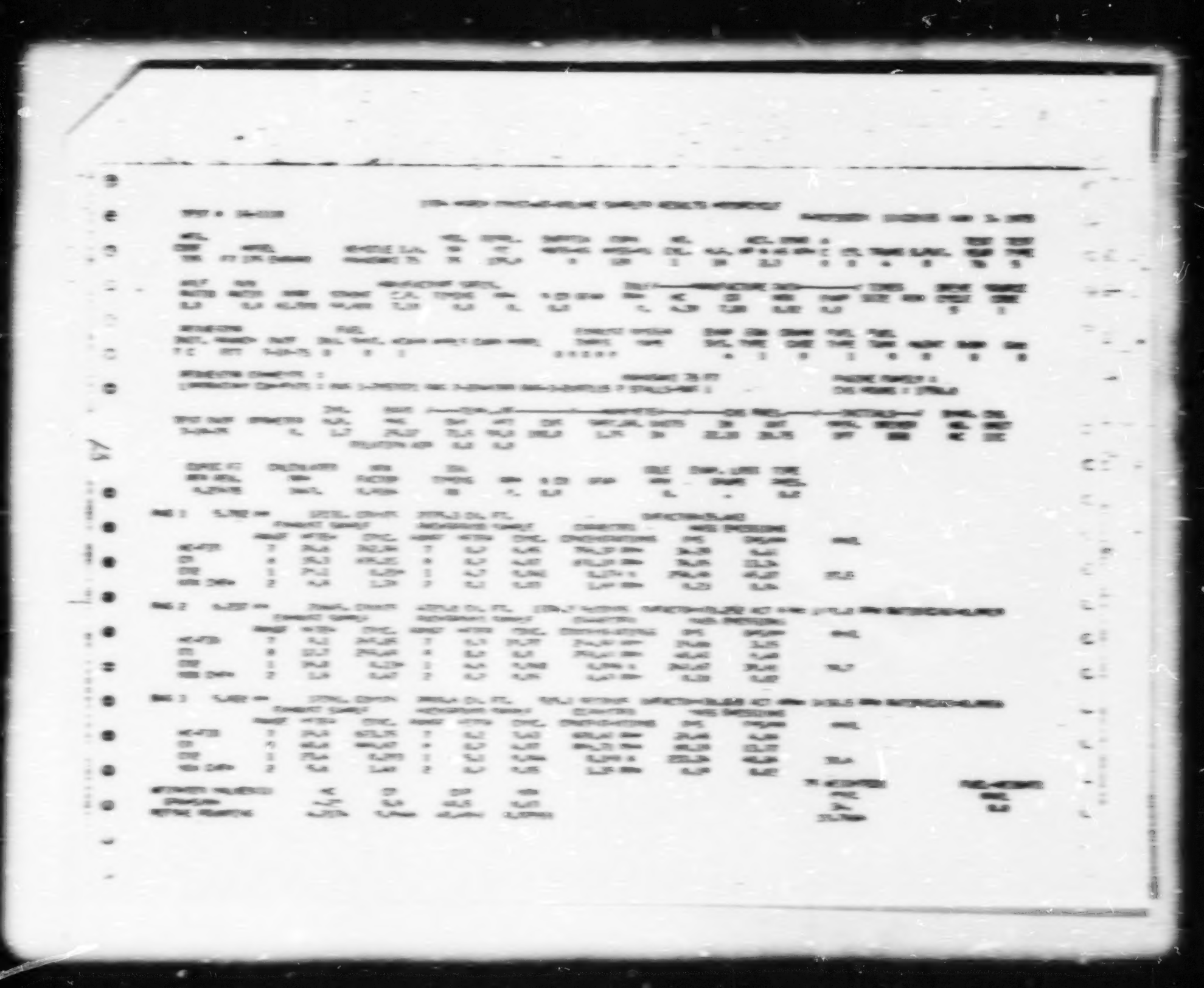

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY PB270853

SUBJECT: Release of Report DATE: Dec. 23, 1975

FROM: Thomas Cachette, SDSB TC

TO: John P. DeKany, Director, ECTD

THRU: Charles Gray, Chief, SDSB CG

The enclosed report is submitted for your approval and clearance for publication.

Title: EPA-Kawasaki Emission Measurement Comparison Test Program

Subject Matter: Comparison testing of three 1975 Kawasaki motorcycles, which took place at Kawasaki in Japan and at EPA, was completed. The ANPSH test procedure, which predates the current procedure, was used.

Conclusion: Emissions and fuel economy compared well between facilities with the exception of CO, which was significantly higher at EPA. Part of the difference is attributed to ambient pressure differences between facilities. It is recommended that factors describing the effect of ambient conditions on emissions and fuel economy be developed.

Approval:

John P. DeKany

John P. DeKany, Director
Emission Control Technology Division

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Appendix III
(Ref.)